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Weed Community and Species Response to Crop Rotation, Tillage, and Nitrogen Fertility[1]

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Abstract: Producers in the northern Great Plains are exploring alternative crop rotations, with the goal of replacing spring wheat-fallow. We characterized the weed associations occurring with tillage system and nitrogen level in two rotations, spring wheat (SW)-fallow (F) and SW-winter wheat (WW)-sunflower (SUN). Weed density was measured 10 yr after initiation of the study. With both rotations, weed community density was highest with no-till. For SW-F, green foxtail, yellow foxtail, and fairy candelabra comprised 99% of the weed community, whereas 13 species were observed in SW-WW-SUN. Fairy candelabra, a rangeland species, was observed only in the no-till system of SW-F. In SW-WW-SUN, no-till favored kochia, Russian thistle, and foxtails, whereas common lambsquarters and annual sowthistle were more common in tilled systems. Nitrogen fertilizer increased crop competitiveness in SW-WW-SUN with no-till, subsequently reducing weed density. Cultural strategies that disrupt weed associations will aid producers in managing weeds.

Nomenclature: Annual sowthistle, *Sonchus oleraceus* L. #[3] SONOL; common lambsquarters, *Chenopodium album* L. # CHEAL; fairy candelabra, *Androsace occidentalis* Lunell; green foxtail, *Setaria viridis* (L.) Beauv. # SETVI; kochia, *Kochia scoparia* (L.) Schrad. # KCHSC; Russian thistle, *Salsola iberica* Sennen & Pau # SASKR; yellow foxtail, *Setaria glauca* (L.) Beauv. # SETLU; wheat, *Triticum aestivum* L.; sunflower, *Helianthus annuus* L.

Additional index words: Cultural strategies, weed association, AMARE, AMBEL, AVEFA, CHEAL, EPHHT, KCHSC, POLCO, SASKR, SETLU, SETVI, SINAR, SONOL, TAROF.

Abbreviations: CT, conventional-till; F, fallow; N, nitrogen; NT, no-till; RT, reduced-till; SUN, sunflower; SW, spring wheat; WW, winter wheat.

INTRODUCTION

The prevalent crop rotation in the drier areas of the northern Great Plains is spring wheat-fallow (Black 1983). Producers rely on fallow to reduce yield variability; however, fallow is detrimental to long-term health and quality of soil (Doran et al. 1996; Peterson et al. 1993). To counter this degradation of soil quality, producers would like to crop more frequently and reduce fallow. More intensive crop rotations are possible with no-till systems, which maintain crop residue on the soil surface, increase precipitation storage (Tanaka and Anderson 1997), and improve water use efficiency of crops (Peterson et al. 1996). Land productivity is increased 50% by no-till continuous cropping compared to spring wheat-fallow (Black et al. 1981).

Producers in the northern Great Plains believe that weeds will be more difficult to control with intensive cropping. This belief is based on previous experiences, as in wet years, producers attempted continuous wheat, but serious weed problems developed. Growing spring wheat continuously resulted in severe infestations of foxtail species (Hume 1982) or wild oat (*Avena fatua* L.) (Donald and Nalewaja 1990), whereas continuous winter wheat led to high densities of downy brome (*Bromus tectorum* L.) (Moyer et al. 1994). Weed densities increased because the weeds and crops had similar life cycles (Froud-Williams 1988).

Density of selected weeds will increase if a cultural practice is imposed continuously on a weed community, a response termed "weed association" (Aldrich 1984). For example, no-till favors kochia and Russian thistle (Koskinen and McWhorter 1986; Miller and Nalewaja 1985), because weed seeds are not buried below their emergence capabilities (Aldrich 1984). Another association is nitrogen (N) fertilizer increasing nitrophilous

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Table 2. Species composition of weed communities in two crop rotations, Mandan, ND.

Bayer code	Species name	Common name	Crop rotation	
			SW-F	SW-WW-SUN
AMARE	*Amaranthus retroflexus* L.	redroot pigweed	X	X
AMBEL	*Ambrosia artemisiifolia* L.	common ragweed	—	X
—	*Androsace occidentalis* Lunell	fairy candelabra	X	—
AVEFA	*Avena fatua* L.	wild oat	—	X
CHEAL	*Chenopodium album* L.	common lambsquarters	X	X
EPHHT	*Euphorbia humistrata* Engelm. ex Gray	prostrate spurge	X	X
KCHSC	*Kochia scoparia* (L.) Schrad.	kochia	X	X
POLCO	*Polygonum convolvulus* L.	wild buckwheat	—	X
SASKR	*Salsola iberica* Sennen & Pau	Russian thistle	—	X
SETLU	*Setaria glauca* (L.) Beauv.	yellow foxtail	X	X
SETVI	*Setaria viridis* (L.) Beauv.	green foxtail	X	X
SINAR	*Brassica kaber* (DC.) L. C. Wheeler	wild mustard	—	X
SONOL	*Sonchus oleraceus* L.	annual sowthistle	—	X
TAROF	*Taraxacum officinale* Weber in Wiggers	dandelion	—	X

[a] X indicates that species was present in rotation; — indicates species was not observed.

plied preemergence at 1.3 kg/ha. Glyphosate controlled weeds present at planting for all crops.

In 1994, we assessed weed flora and seedbank composition in the spring wheat plots of both rotations. For weed flora, eight 0.25-m^2 quadrats were randomly arranged in a W pattern across each plot, with quadrats 10 m apart. Weed seedlings were counted and identified in early June, before in-crop herbicides were applied, and in August, before harvest. For seedbank composition, 20 soil cores, 3 cm in diam and 12 cm deep, were collected and composited before spring wheat planting. Sampling sites were arranged in a W pattern across the plot, with sampling sites 6 m apart. Procedures for processing soil samples and identifying weed seeds were reported previously by Schweizer and Zimdahl (1984).

Treatment effects were similar between weed flora and seedbank data, with two exceptions. Therefore, only weed flora data are presented, with the seedbank exceptions discussed in the text. Weed species observed are listed in Table 2. Green and yellow foxtail plants were not counted separately because of difficulty in distinguishing between seedlings of these species. Weed flora densities are the sum of both assessment dates and were analyzed by ANOVA. Tillage by N fertility interactions were analyzed as a split-split plot design, and except for foxtails, species were analyzed separately within rotation because different weed species were present in each rotation. Treatment means were separated by either Fisher's Protected LSD test or Duncan's new multiple range test at the 0.05 level of probability.

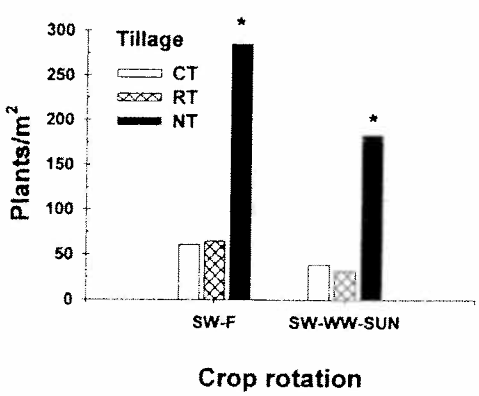

Figure 1. Weed community density in SW-F and SW-WW-SUN, as affected by tillage system. Data were averaged across N treatments. An asterisk indicates that the NT mean differs from the CT and RT means within each rotation.

RESULTS AND DISCUSSION

Weed Community Response to Rotation and Tillage. *Weed community density.* Weed density was highest in NT with both rotations. For SW-F, weed density increased from 62 plants/m^2 in CT to 292 plants/m^2 for the NT (Figure 1). A similar trend occurred with SW-WW-SUN. With both rotations, the magnitude of change was approximately fivefold when comparing weed densities in NT with CT. With most cropping systems, weed densities tend to increase with NT (Blackshaw et al. 1994; Froud-Williams 1988).

Weed community diversity. Integrating crops with different life cycles in a rotation leads to diversity of the weed community and minimizes the predominance of any one species (Froud-Williams 1988; Haas and Streibig 1982). In our study, foxtails and fairy candelabra comprised 99% of the weed community in SW-F. In contrast, the weed community in SW-WW-SUN was more diverse, with eight species—kochia, yellow and green foxtails,

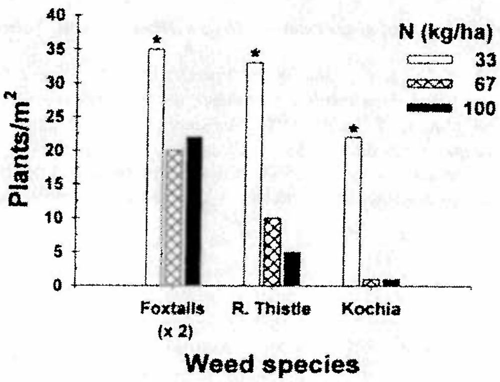

Figure 4. Response of three species to N fertilizer in the NT system of SW-WW-SUN. An asterisk indicates that the 33 kg N/ha mean differs from the other N treatment means within each species. The × 2 means that the foxtail density should be doubled for correct density.

when N was applied at 33 kg/ha, but only 58 weeds/m^2 were present when N was applied at 100 kg/ha (data not shown).

Higher N levels increased yield of all crops in this rotation (Black and Tanaka 1997), indicating that N was needed to maximize crop yields. Adding N also increased crop competitiveness with weeds, subsequently reducing weed growth and seed production.

Management Implications. This study demonstrates the ecological tendency of weeds to associate with cultural practices, such as fairy candelabra proliferating in the NT system with SW-F and the weed community density increasing in NT with SW-WW-SUN. Producers can counter this trend of increased weed density with NT by either rotating tillage systems (Figure 2), changing the crop sequence (Blackshaw et al. 1994), or alternating different rotations on the same field. These strategies will disrupt weed associations with NT, subsequently reducing weed densities in future crops.

Another potential weed management strategy is N placement (Di Tomaso 1995). For example, green foxtail responds more to N than spring wheat (Peterson and Nalewaja 1992). However, strategic N placement can improve crop competitiveness and subsequently inhibit green foxtail growth (O'Donovan et al. 1997). Applying N fertilizer early in the growing season to winter wheat reduces green foxtail densities because of greater crop canopy development (Black and Siddoway 1977). A second practice, banding N fertilizer, also reduces green foxtail densities because of improved crop competitiveness (O'Donovan et al. 1997). In contrast, if producers are not careful with N management, weed problems can increase because excessive N fertilizer can favor weed growth and higher weed densities in future crops, as shown with fairy candelabra in SW-F.

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